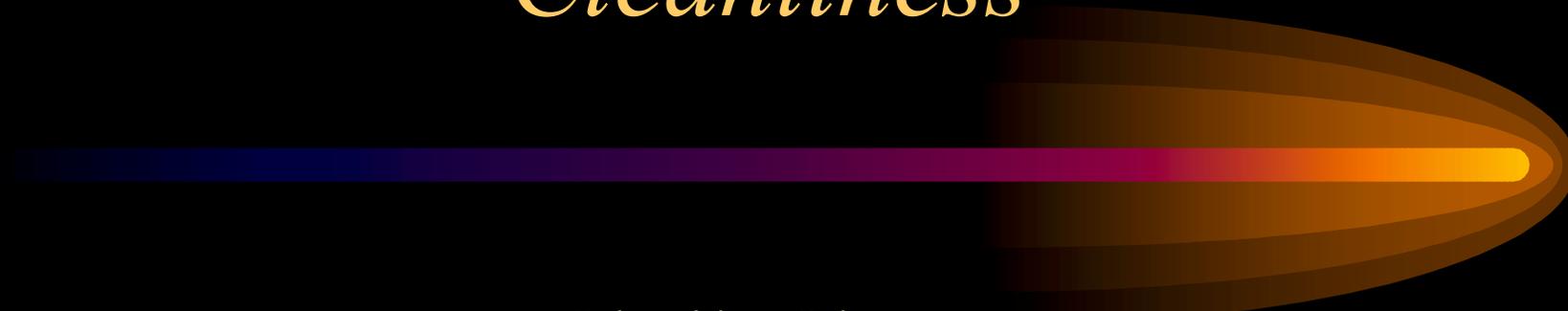


*Precision Clean Hardware:  
Maintenance of Fluid System  
Cleanliness*



Sheila Sharp

Materials & Processes

International Space Station Program

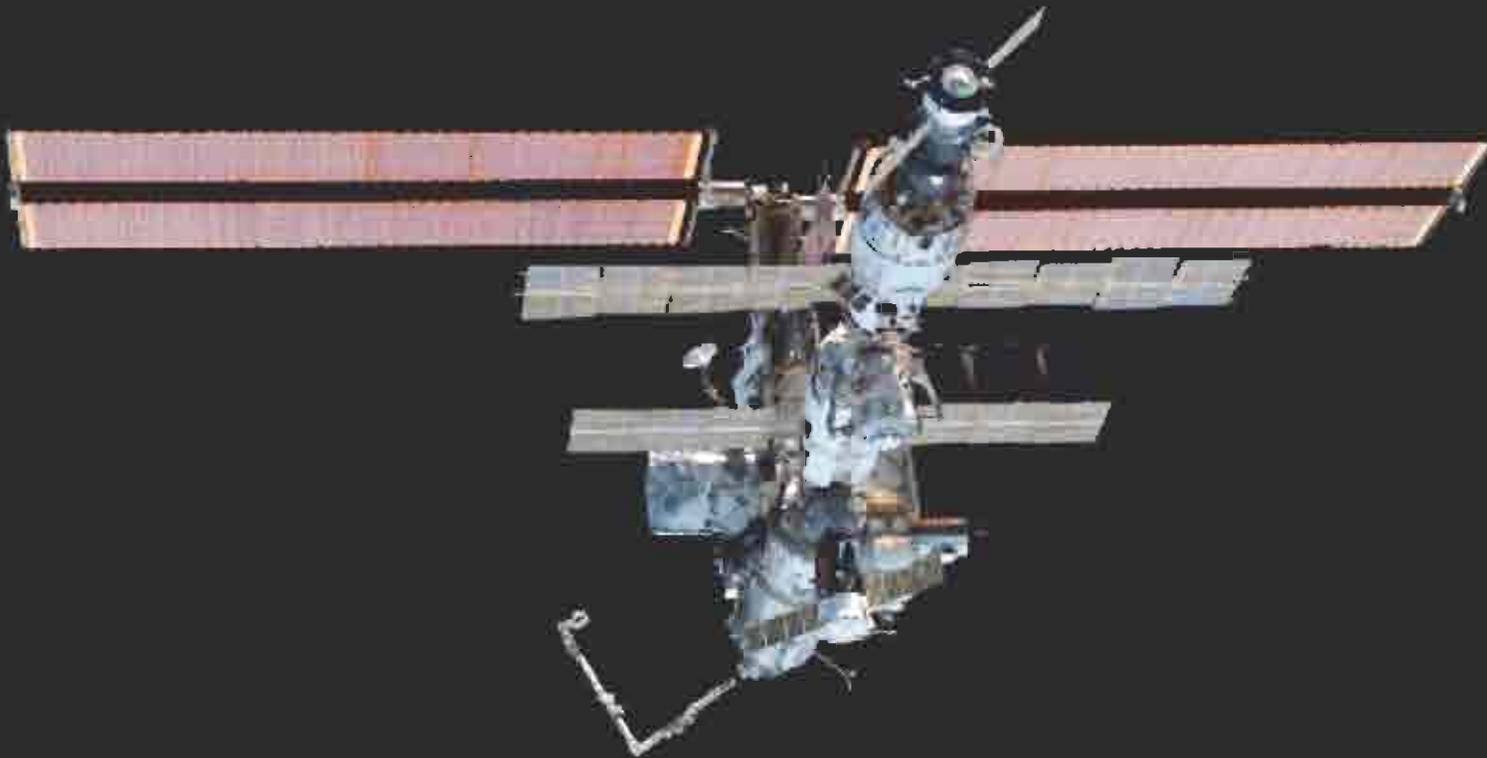
September 18, 2002

# *Acknowledgements*

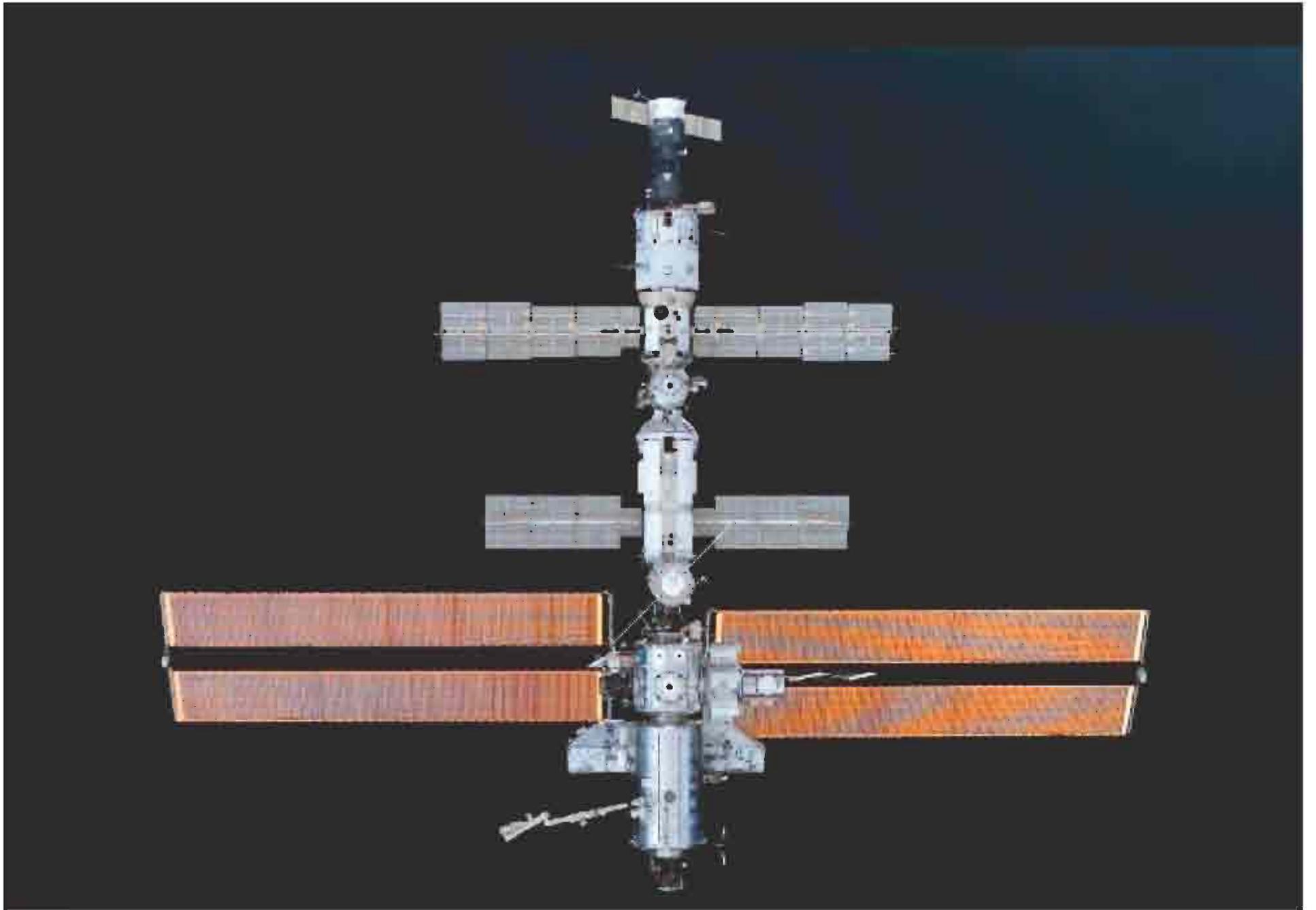
- All work conducted under NASA contract
  - NAS15-10000 International Space Station Integration and Operations
- Co-authors
  - NASA
    - Dr. Mike Pedley, Tim Bond
  - Boeing
    - Joseph Quaglino, Mary Jo Lorenz, Michael Bentz, Richard Banta, Nancy Tolliver, John Golden, Ray Levesque, and Sarah Densmore



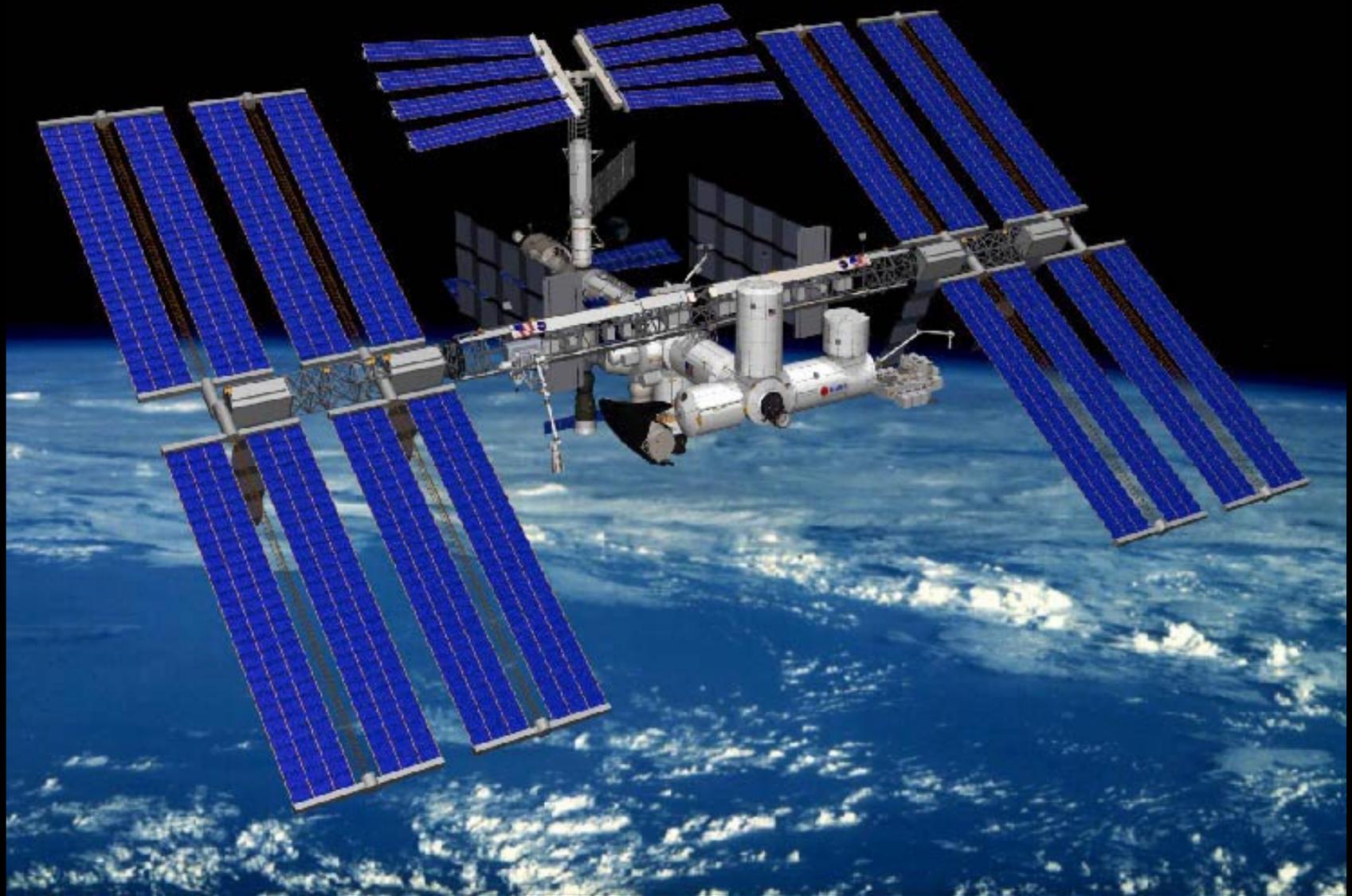
S110E6027



S110E5905

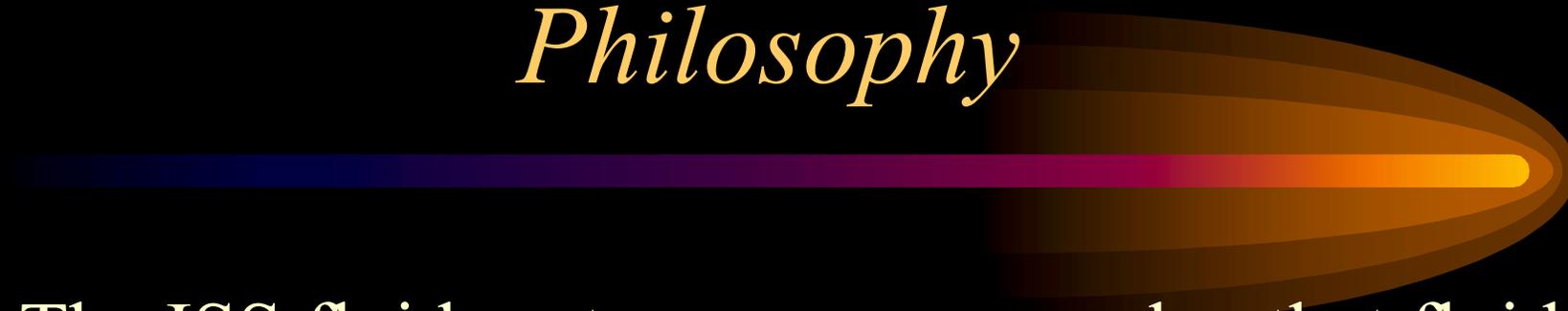


S110E5932



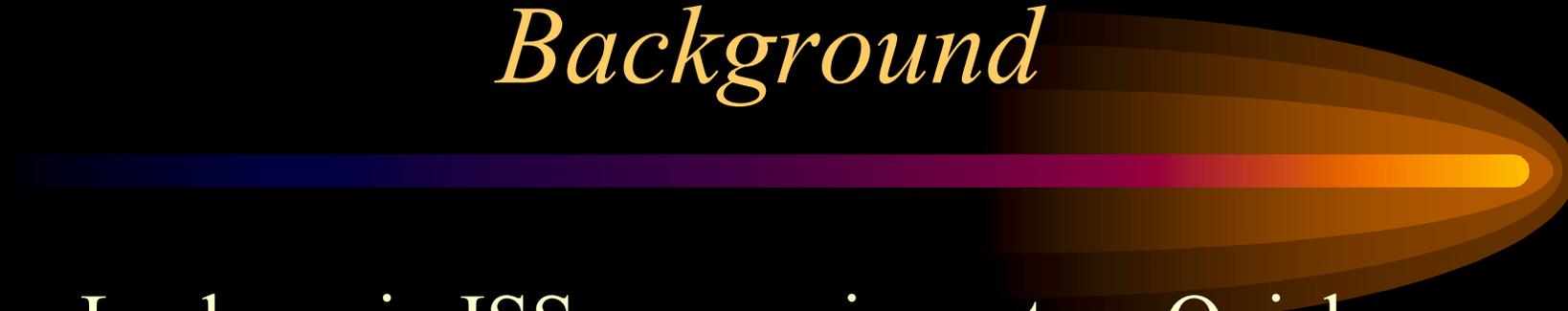
Assembly Complete - 2007

# *Philosophy*



- The ISS fluid systems are so complex that fluid system cleanliness cannot be verified at the assembly level.
- A “build clean / maintain clean” approach was used by all major fluid systems.
  - Verify cleanliness at the detail and subassembly level.
  - Maintain cleanliness during assembly.

# *Background*



- Leakage in ISS ammonia system Quick Disconnect (QD) hardware led to the establishment of a “Clean Team”.
- Analysis of contaminants indicated multiple contamination sources.
- “Clean Team” was to identify and eliminate as many contamination sources as possible.

# *Background cont'd*

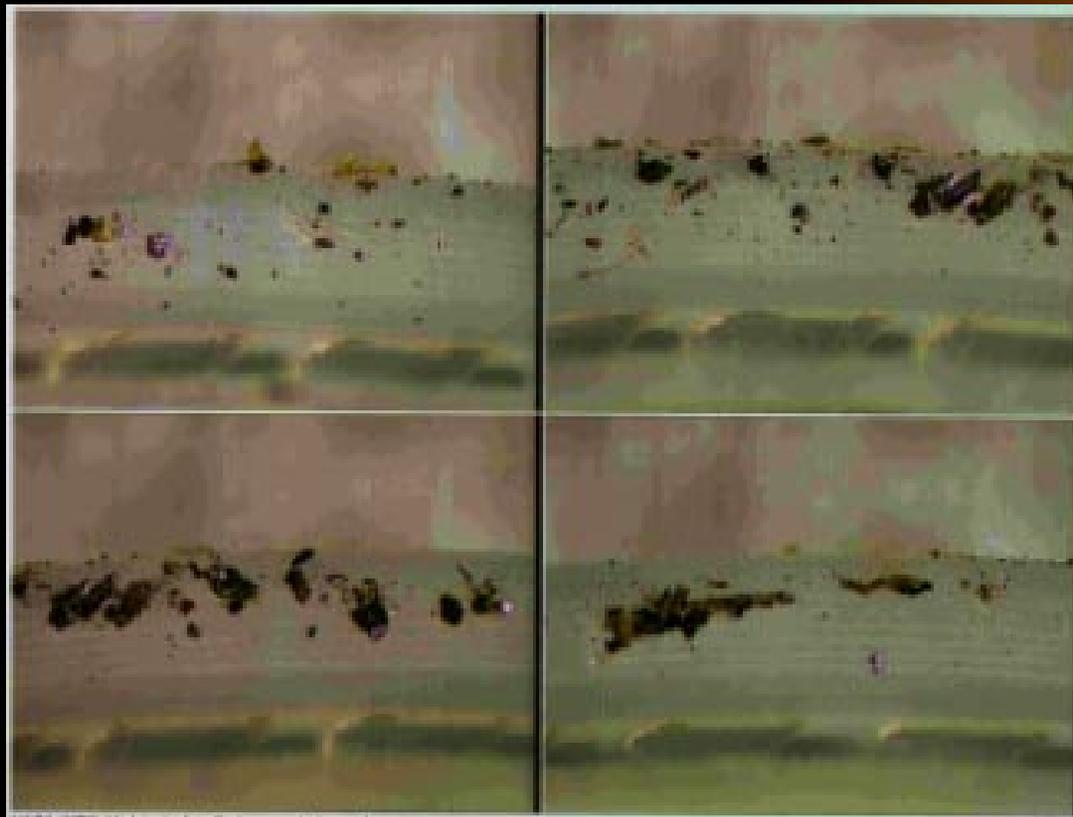


Figure 1. Contaminated QD Seal

## *Background cont'd*

- Clean Team visited the ISS hardware manufacturing sites and reviewed all procedures used to produce and maintain precision cleaned hardware.
- Result was a set of recommendations or “best practices” to be used in the manufacture of precision cleaned hardware.

# *Documentation*



- ISS-PI-044,  
Maintenance of Fluid Systems Cleanliness
- SSP 30573,  
Space Station Program Fluid Procurement and Use  
Control Specification

# *Training*

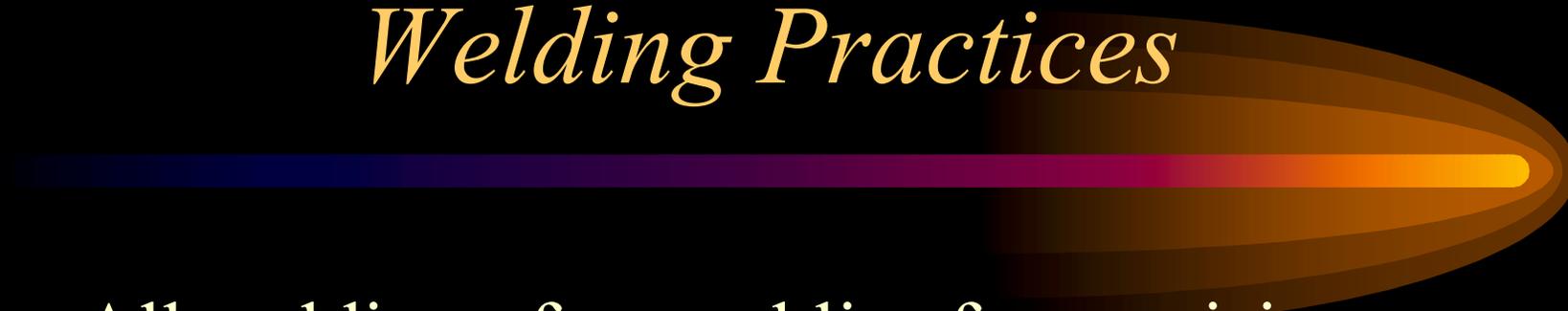


- All personnel working around precision cleaned hardware in the ISS program are required to attend TR001484, ISS, Maintenance of Fluid Systems Cleanliness training course

# *Definition of Precision Cleanliness*

- Clean rooms are enclosed, environmentally controlled areas for the performance of work on contamination sensitive hardware or assemblies. Consists of Class 100,000 or cleaner.
- Precision cleanliness shall be maintained to program requirements (e.g. SN-C-0005 Level 200)
  - SN-C-0005 Level 200 states that there should not be any particles of a size greater than 200 microns present in a 100 milliliter sample of fluid from the system

# *Welding Practices*



- All welding of assemblies for precision cleaned hardware will be performed in a dedicated class 100,000 Clean Work Area (CWA)
- Temporary tents and local monitors may be required to maintain the 100k environment

## *Welding Practices cont'd*



- Accurate monitoring of local contamination is required
- Portable particle counters shall be located as close to the work area as possible during tube preparation and welding

## *Welding Practices cont'd*

- A proven method of contamination prevention such as tube plugs is required
- Installation and removal of such plugs shall be tracked and independently verified by Quality Assurance
- Prior to plug removal, the tube ID shall be cleaned with a swab and approved solvent
- Positive back pressure shall be maintained as the plug is removed

## *Welding Practices cont'd*



Figure 2. Damage from not removing a plug

## *Welding Practices cont'd*

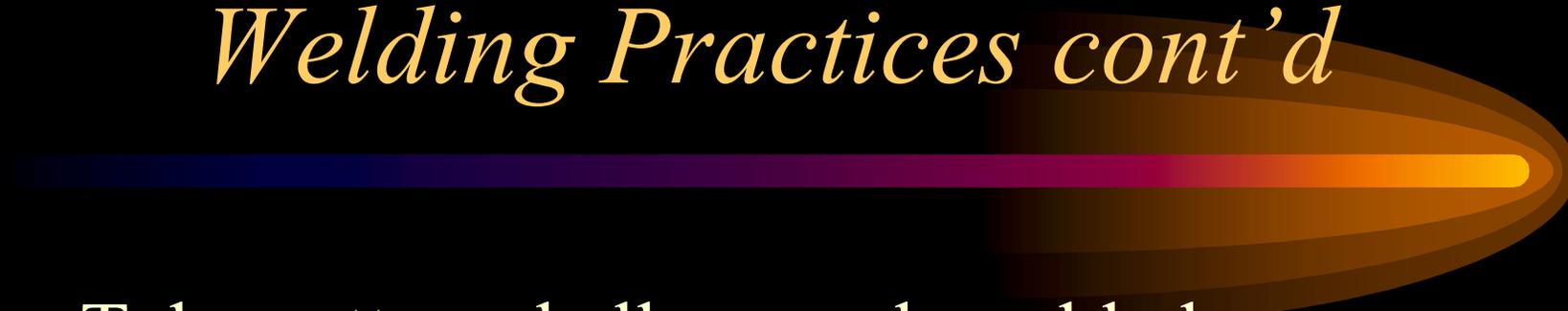


Figure 3. More damage from not removing a plug

## *Welding Practices cont'd*

- After each tube preparation and prior to welding, a high-velocity gas blow down shall be performed
- Gas velocity target shall be the maximum attainable using a 90 psig purge gas source
- CAUTION, use only approved purge gases per SSP 30573

## *Welding Practices cont'd*



- Tube cutters shall use a sharp blade, changed frequently
- Cutting shall be performed with minimal cutting pressure to prevent particle generation

# *Tube Facing Practices*

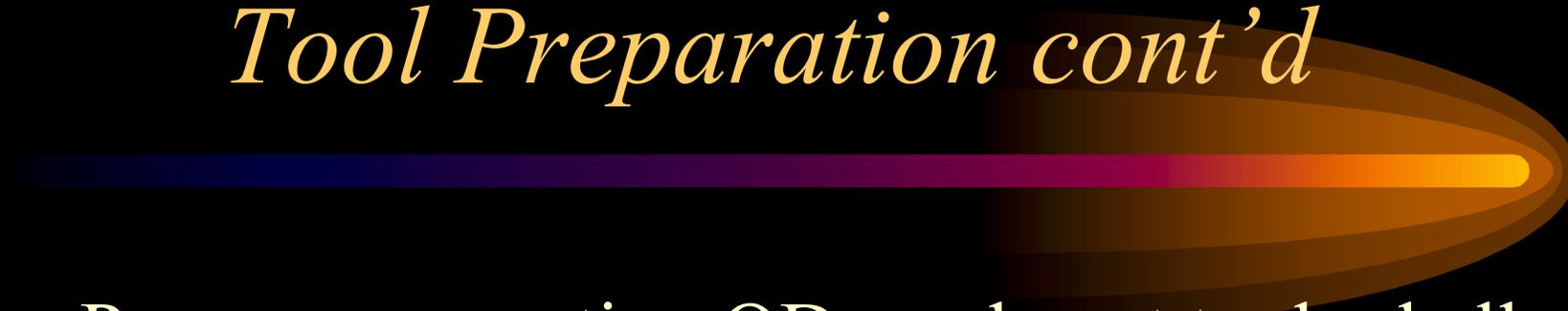
- Vacuum shall be used during tube facing operations
- Whenever possible, facing operations shall be performed away from the weld assembly area
- Tube facing shall be accomplished without the use of cutting oils, lubricants or coolants
- Abrasives, such as sandpaper or abrasive pads shall not be used inside tubes or when unprotected internal surfaces are exposed

# *Tool Preparation*



- Inspection tools (e.g., borescopes) that may be exposed to precision cleaned systems hardware shall be visibly cleaned and maintained clean
- Tools used in weld preparation and welding, such as cutters, weld heads and files, shall be visibly cleaned and maintained clean (e.g. bagged when not in use).

## *Tool Preparation cont'd*



- Purge caps, mating QDs and vent tools shall be precision cleaned to at least the level of the associated system and bagged after use

# *Purge Gas Practices*

- Purge gas used during facing and welding shall meet the hydrocarbon and particulate controls per SSP 30573
- Purge gas used during facing and welding shall be supplied through precision cleaned low NVR/particulate tubing such as polyethylene, nylon, Teflon, or ethyl vinyl acetate
- Standard grade Tygon is not suitable

# *Ground Support Equipment*

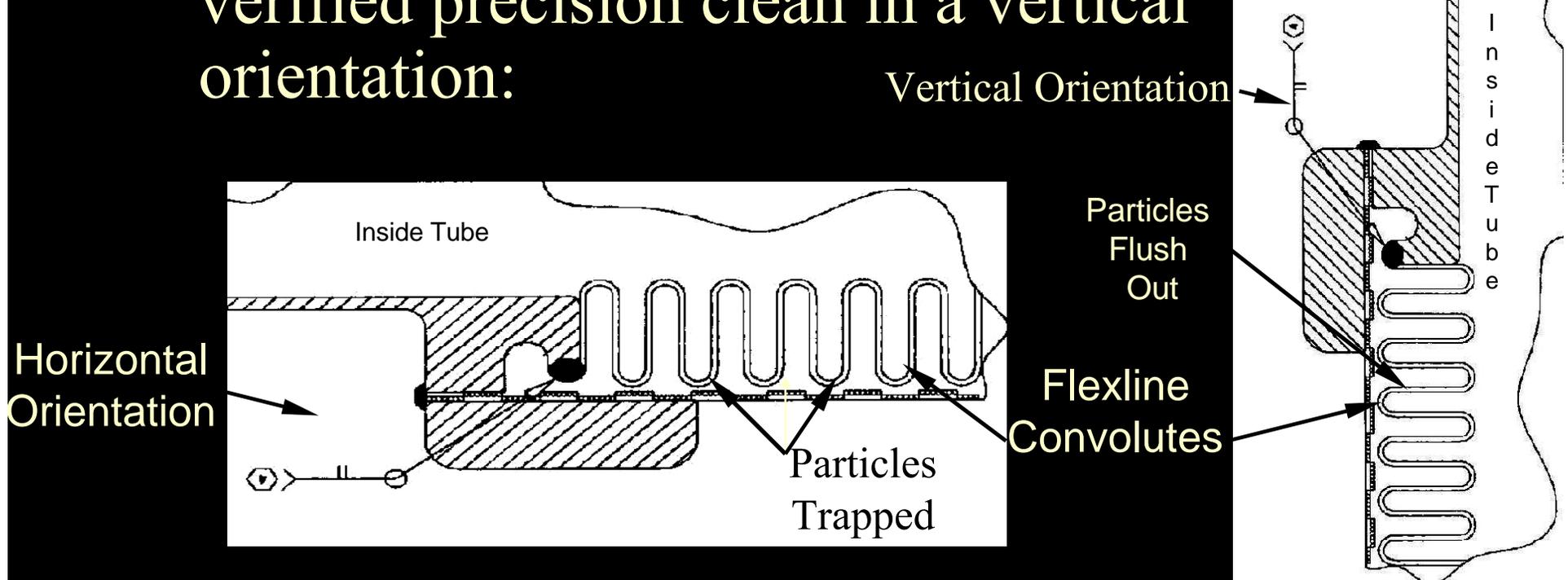
- Ground Support Equipment (GSE) that interfaces with precision cleaned flight fluid systems shall incorporate interface filters per SSP 30573
- These filters shall be located as close to the interface as possible
- Outlet lines require filters if it is determined that reverse flow could occur during the servicing or deservicing operation

## *Ground Support Equipment cont'd*

- GSE that interfaces with precision cleaned flight fluid systems shall be cleaned to at least the level of cleanliness of the flight hardware
- GSE fluid hardware, such as hoses and servicing units shall be handled with the same cleanliness procedures as flight hardware

# *Cleaning Convoluted Flex Hoses*

- Cleaning Convoluted Flex hoses requires special attention
- Detail flex hoses shall be cleaned and verified precision clean in a vertical orientation:



# *Cleaning Convoluted Flex Hoses*

## *cont'd*



- Cleanliness is verified by sampling the rinse fluids. The sample must meet the flex hose engineering cleanliness requirement
- For flex hoses that are one inch or greater in diameter
  - Rinse fluid is applied to all internal surfaces with a high pressure nozzle

# *Cleaning Convoluted Flex Hoses*

## *cont'd*



- For flex hoses that are less than one inch diameter
  - Use of high pressure nozzles is preferred, but cleaning by flushing the rinse fluid through the length of the hose with agitation is acceptable

# *Maintenance of System Cleanliness*

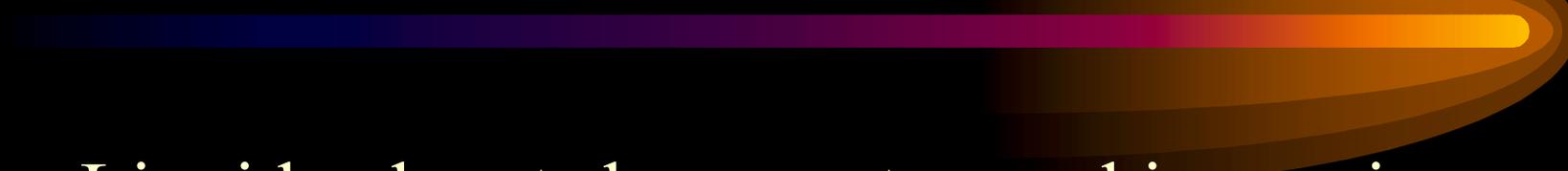


- All precision cleaned open tubes and lines must be protected, i.e. wrapped or bagged with approved materials, as soon as possible after fabrication
- Tubes and lines must remain wrapped until final installation

# *Oxygen Systems*

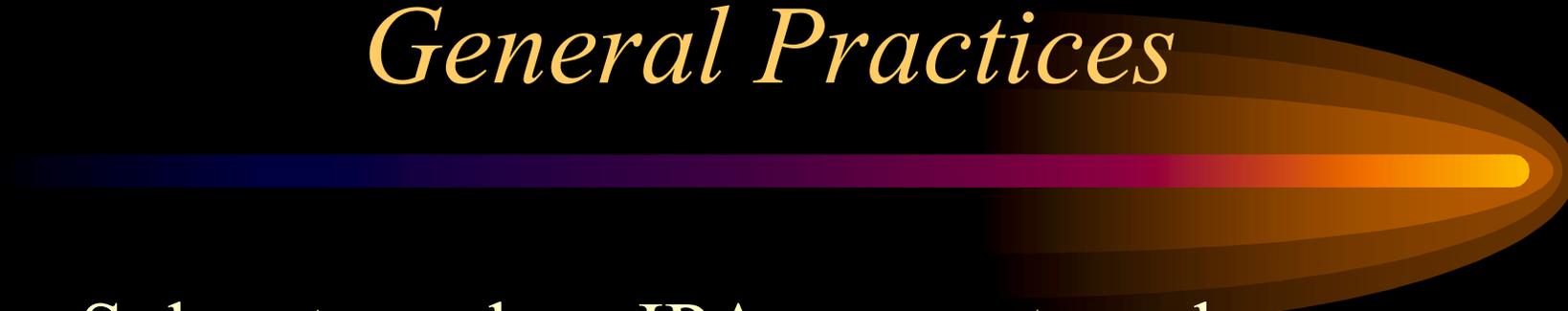
- Regulators used during purging operations shall have O<sub>2</sub> compatible grease
- Purge tubing must be O<sub>2</sub> compatible
- Bagging materials used to store O<sub>2</sub> components shall be cleaned to the same level of cleanliness as the O<sub>2</sub> hardware, and must be O<sub>2</sub> compatible

# *Sampling for Residual Solvent*



- Liquid solvents become trapped in crevices or absorbed into soft goods.
- Some fluid systems are quite sensitive to these contaminants.
- ISS uses a 24-hour “lock up”, to ensure gas sampling accurately reflects residual solvent concentration.

# *General Practices*



- Solvents such as IPA, reagent grade or better, shall be filtered to 10 microns or better prior to use
- Precision cleaned hardware that has been welded shall remain properly capped during the x-ray operations to avoid potential contamination

## *General Practices cont'd*

- Hardware that has not been precision cleaned shall not be brought into the vicinity of unprotected precision cleaned flight hardware
- Flight hardware must be wrapped in approved packaging material
- All precision cleaning fluid systems configured for flight shall have integrity seals installed

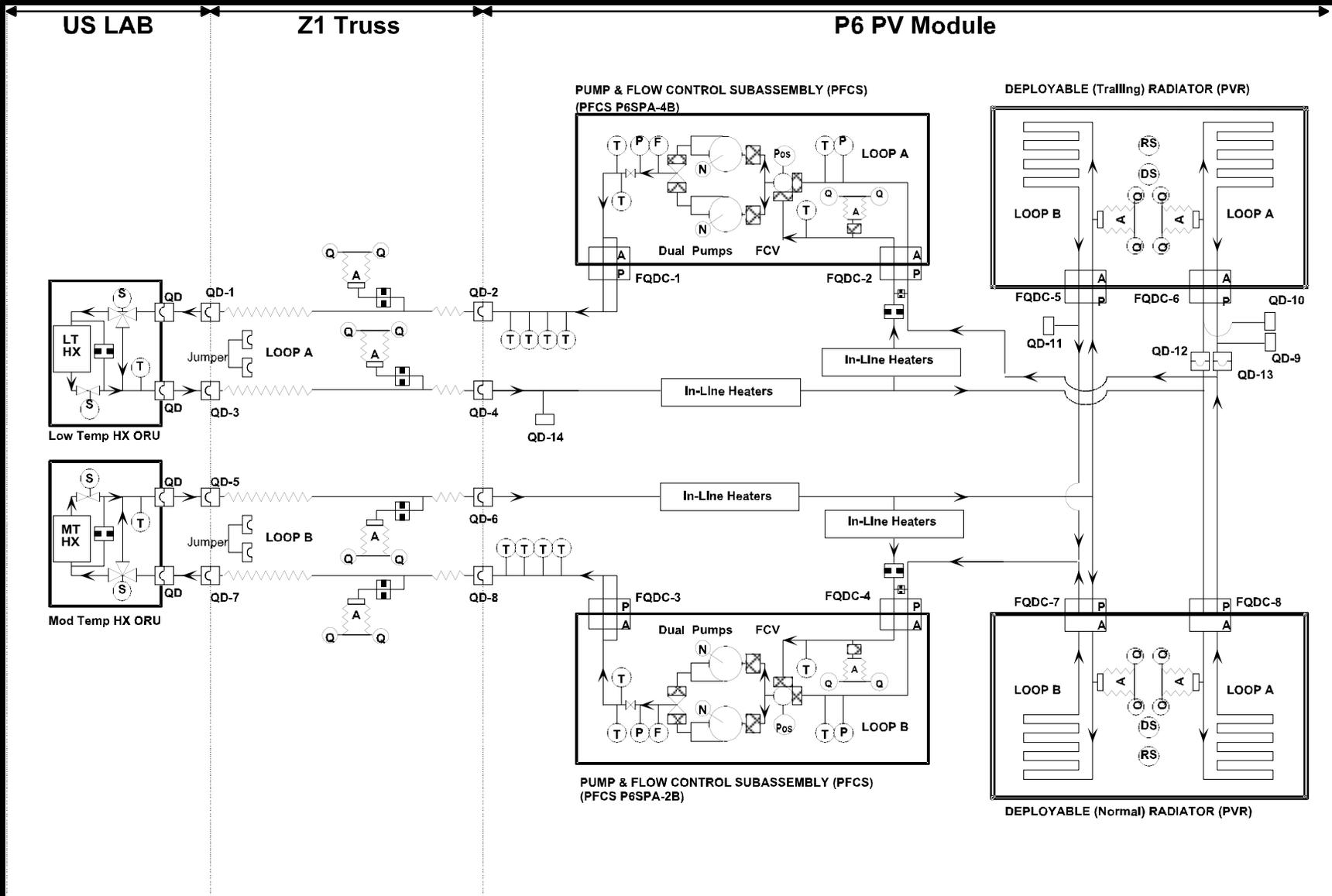
## *General Practices cont'd*

- Precision cleaned hardware can not be exposed to an uncontrolled environment.  
This includes flow benches providing 100,000 CWA or better during inspections
- Bag hardware that must be transported outside the clean room
- Clean room gloves are required when handling any precision cleaned flight hardware

# *Summary*



- Many of the “best practices” are simple and straightforward.
- However, the different heritage ISS organizations had different priorities for meeting the same end product requirements.
- The “Clean Team” has provided a common focus, and significantly reduced the incidents of contamination induced failures.



External Thermal Control System Schematic